

High Thermal Conductivity NARloy-Z-Diamond Composite Combustion Chamber Liner For Advanced Rocket Engines

Biliyar N. Bhat – NASA-MSFC

David Ellis, NASA-GRC

Jogender Singh – Pennsylvania State University

Abstract

Advanced high thermal conductivity materials research conducted at NASA Marshall Space Flight Center (MSFC) with state of the art combustion chamber liner material NARloy-Z showed that its thermal conductivity can be increased significantly by adding diamond particles and sintering it at high temperatures. For instance, NARloy-Z containing 40 vol. % diamond particles, sintered at 975°C to full density by using the Field assisted Sintering Technology (FAST) showed 69% higher thermal conductivity than baseline NARloy-Z. Furthermore, NARloy-Z-40vol. %D is 30% lighter than NARloy-Z and hence the density normalized thermal conductivity is 140% better. These attributes will improve the performance and life of the advanced rocket engines significantly. By one estimate, increased thermal conductivity will directly translate into increased turbopump power up to 2X and increased chamber pressure for improved thrust and I_{SP} , resulting in an expected 20% improvement in engine performance.

Follow on research is now being conducted to demonstrate the benefits of this high thermal conductivity NARloy-Z-D composite for combustion chamber liner applications in advanced rocket engines. The work consists of a) Optimizing the chemistry and heat treatment for NARloy-Z-D composite, b) Developing design properties (thermal and mechanical) for the optimized NARloy-Z-D , c) Fabrication of net shape subscale combustion chamber liner, and d) Hot fire testing of the liner for performance. FAST is used for consolidating and sintering NARloy-Z-D. The subscale cylindrical liner with built in channels for coolant flow is also fabricated near net shape using the FAST process. The liner will be assembled into a test rig and hot fire tested in the MSFC test facility to determine performance. This paper describes the development of this novel high thermal conductivity NARloy-Z-D composite material, and the advanced net shape technology to fabricate the combustion chamber liner. Properties of optimized NARloy-Z-D composite material will also be presented.